Dryland Soil Carbon and Nitrogen after Thirty Years of Tillage and Cropping Sequence

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Introduction

- Increased conservation of soil C and N through improved management practices are needed to enhance C sequestration for C trading, reduce the rate of N fertilization and N losses through leaching, denitrification, and volatilization, and mitigate the emissions of greenhouse gases (CO_2, N_2O, and CH_4) from agroecosystems.
- Soil C and N storage have been reduced by 30 to 50% of their original contents in the last 50 to 100 yr using traditional farming systems, such as conventional tillage with crop-fallow in the northern Great Plains.
- Limited information exists on the long-term (30 yr) effects of management practices on soil C and N conservation.

Objectives

- Evaluate the 30-yr influence of tillage and cropping sequence combination on crop biomass (stems + leaves) returned to the soil and soil organic C (SOC), inorganic C (SIC), total N (STN), NH_4-N, and NO_3-N contents at the 0-120 cm depth under dryland cropping systems in the northern Great Plains,
- Quantify C and N sequestration rates, and
- Examine if soil total C (STC) can be used to estimate SOC in dryland cropping systems where SIC contents are higher than in irrigated cropping systems

Wheat

Barley

Pea

Fallow

No-till *Conventional till*

Treatments

Soil sampling

- NTCW = No-till continuous spring wheat
- STCW = Spring till continuous spring wheat
- FSTCW = Fall and spring till continuous spring wheat
- FSTW-B/P = Fall and spring till spring wheat-barley (1984-1999), followed by spring wheat-pea (2000-2013)
- STW-F = Spring till spring wheat-fallow (traditional system)

Design: Randomized complete block with four replications
Location: Froid, Montana
Duration: 1984-2013

Results

- Mean annualized crop biomass yield was lower in STW-F than the other treatments (***Fig. 1***).
- The SOC and SIC at 0-7.5 cm was greater in STCW than the other treatments, except NTCW (***Fig. 2***). The SIC at 90-120 cm was also greater in NTCW and STCW than the other treatments.
- The SOC at 0-7.5 cm decreased linearly with year from 1984 to 2003 (***Fig. 3***). The rate of decrease was 99 to 130 kg C ha^{-1} yr^{-1} lower in STCW and NTCW than STW-F (***Table 1***).
- The SOC and STC at 0-120 cm were linearly related (***Fig. 4***).
- The STN at 0-7.5 and 15-30 cm was also greater in STCW and NTCW than the other treatments (***Fig. 5A***).
- As with SOC, STN also declined with year (***Fig. 5B***). The rate of decline was 8 to 19 kg N ha^{-1}yr^{-1} lower with NTCW and STCW than the other treatments (***Table 1***).
- Soil NH_4-N content at 0-7.5 cm was greater in STCW and FSTCW than the other treatments (***Fig. 6***).
- Soil NO_3-N content at 0-7.5, 7.5-15, and 90-120 cm was usually greater in FSTCW than the other treatments (***Fig 6***).

Figure 1. *Effect of tillage and cropping sequence combination on mean annualized crop biomass (stems + leaves) residue returned to the soil from 1984 to 2013.*

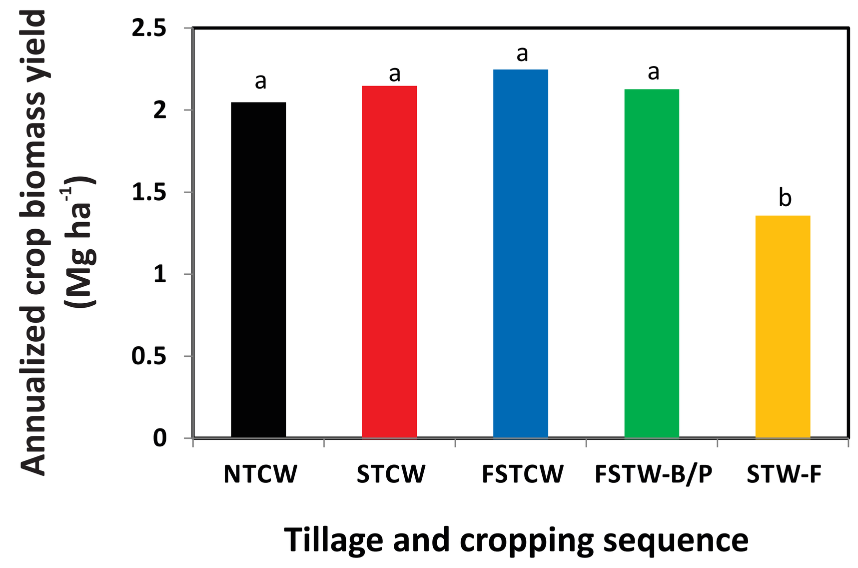

Figure 2. *Soil organic (SOC) and inorganic C (SIC) contents at the 0-120 cm depth as influenced by 30 yr of tillage and cropping sequence combination.*

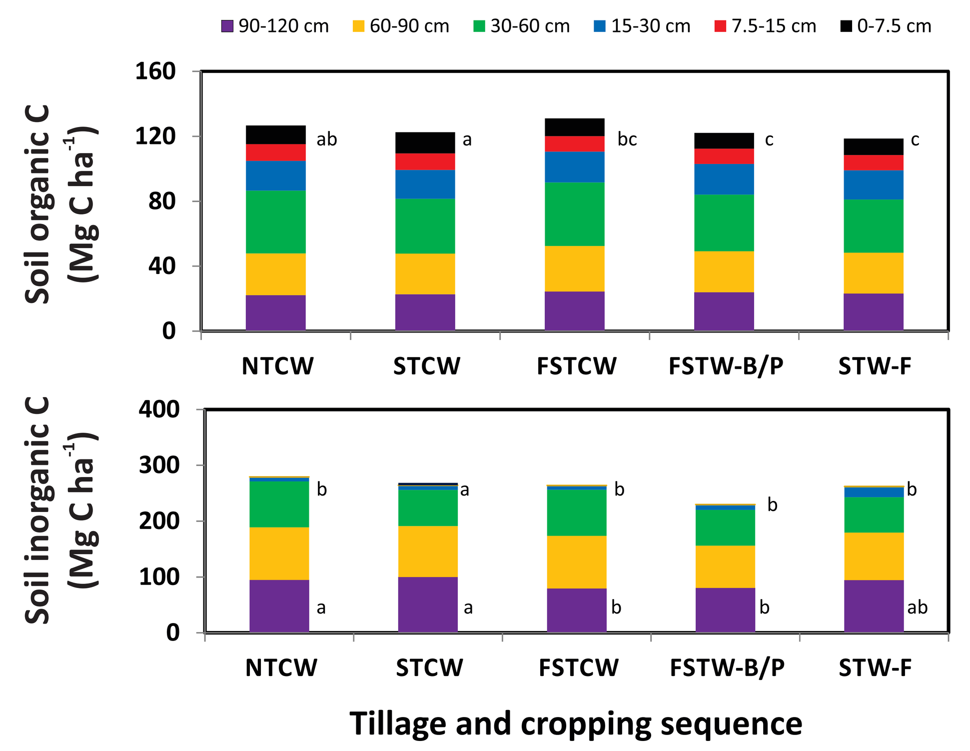

Figure 3. *Relationship between soil organic C (SOC) at the 0-7.5 cm depth and year as influenced by tillage and cropping sequence combination.*

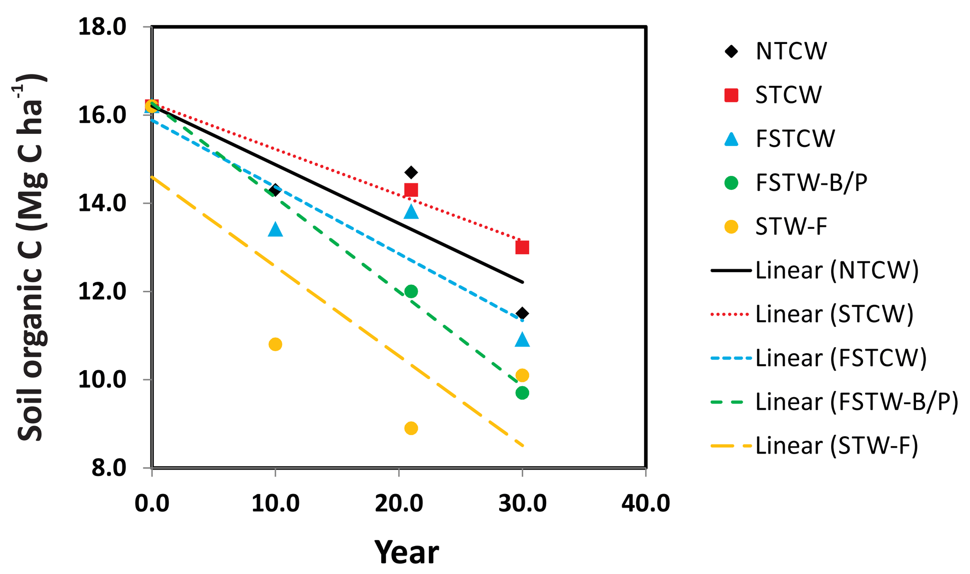

Table 1. *Regression coefficients for the relationships between soil organic C (SOC) and total N (STN) at the 0-7.5 cm depth with year as affected by tillage and cropping sequence combination for **Figs. 3** and **5B**.*

Tillage and cropping sequence	Regression coefficients for SOC			
	a†	b‡	R^2	*P*
NTCW	16.2	-0.133	0.78	0.11
STCW	16.3	-0.104	0.98	0.07
FSTCW	15.9	-0.151	0.83	0.09
FSTW-B/P	16.2	-0.214	0.99	0.04
STW-F	14.6	-0.203	0.67	0.18
	Regression coefficients for STN			
NTCW	1.74	-0.016	0.96	0.01
STCW	1.69	-0.005	0.12	0.78
FSTCW	1.71	-0.020	0.95	0.02
FSTW-B/P	1.71	-0.026	0.88	0.22
STW-F	1.58	-0.024	0.65	0.20

† Intercept (Units are Mg C ha^{-1} for SOC and Mg N ha^{-1} for STN).
‡ Slope (Units are Mg C ha^{-1} yr^{-1} for SOC and Mg N ha^{-1} yr^{-1} for STN).

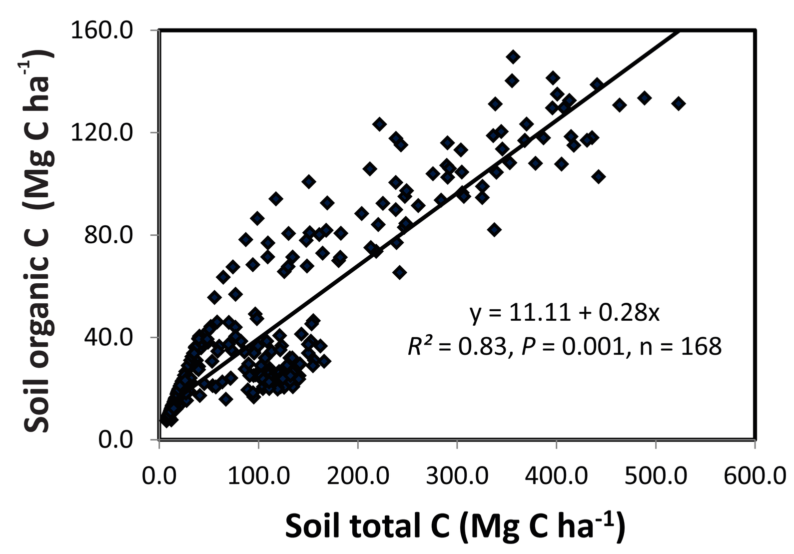

Figure 4. *Relationship between soil total C (STC) and organic C (SOC) at the 0-120 cm depth.*

Discussion & Conclusions

- Reduced soil disturbance and greater amount of crop residue returned to the soil increased C and N storage and lowered their rate of decline in NTCW and STCW than STW-F at the surface layer.
- Soil total C can be used to predict SOC in dryland cropping systems which can reduce the time and cost of soil analysis.
- Increased tillage intensity increased soil available N (NH_4-N and NO_3-N contents).
- Improved management practices, such as reduced tillage with continuous nonlegume cropping, can sequester C at 99 to 130 kg C ha^{-1} yr^{-1} and N at 8 to 19 kg N ha^{-1} yr^{-1} in the surface layer compared with the traditional conventional tillage with crop fallow in dryland cropping systems in the northern Great Plains.

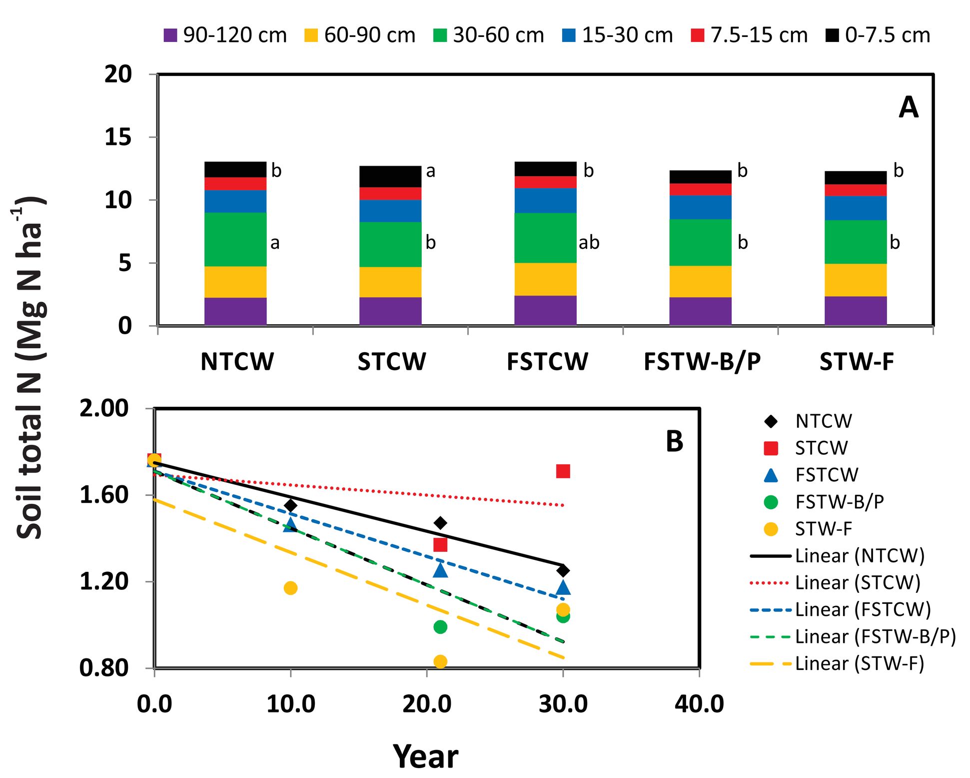

Figure 5. **(A)** *Soil total N (STN) content at the 0-120 cm depth as influenced by 30 yr of tillage and cropping sequence combination.* **(B)** *Relationship between STN at the 0-7.5 cm depth and year as influenced by tillage and cropping sequence combination.*

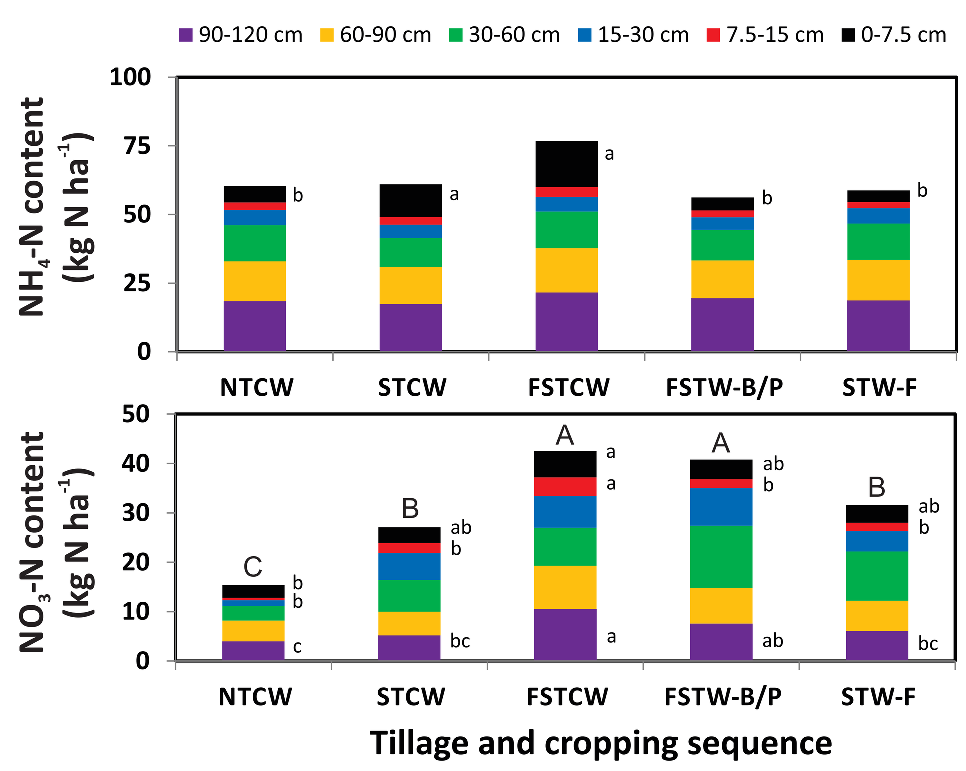

Figure 6. *Soil NH_4-N and NO_3-N contents at the 0-120 cm depth as influenced by 30 yr of tillage and cropping sequence combination.*

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